CLAIMS

1 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough.

2 A flow meter as claimed in claim 1, wherein the holdup measuring device includes a capacitive device which measures the dielectric constant of the flowing fluids.

3 A flow meter as claimed in claim 1, wherein the holdup measuring device includes a resistive device measuring the resistivity of the flowing fluids.

4 A flow meter as claimed in claim 1, wherein the holdup measuring device measures volume fractions in the range of 0 – 100% water.

5 A flow meter as claimed in claim 4, wherein the holdup measuring device comprises a combination of capacitive and resistive measurements on the flowing fluids.

6 A flow meter as claimed in claim 2, wherein a capacitance sensor comprises at least one excitation electrode provided with at least one cutout in which at least one measurement electrode is disposed, the electrodes being applied against a pipe through which the fluids flow.

7 A flow meter as claimed in claim 6, further comprising a system for maintaining the electrodes at the same potential and for measuring the current output by the measurement electrode, and a processing system for determining the dielectric constant of the fluids from the measured current.

8 A flow meter as claimed in claim 6, wherein all of the conductors liable to give rise to interference that are situated in the vicinity of the sensor are maintained at the potential of the excitation electrode.

9 A flow meter as claimed in claim 6, wherein the excitation electrode is connected to the general ground of a power supply.

10 A flow meter as claimed in claim 7, wherein the excitation electrode constitutes a floating ground for the current measuring system.

11 A flow meter as claimed in claim 10, wherein the current measuring system comprises a first amplification stage referenced relative to the potential of the excitation electrode, and a second amplification stage arranged to bring the reference of the output signal to the general ground.

12 A flow meter as claimed in claim 11, further comprising shielding, electrically connected to the excitation electrode, around the measurement electrode and around the first amplification stage.

13 A flow meter as claimed in claim 12, wherein the shielding is extended by a shielded cable along which a conductor passes that connects the measurement electrode to the amplification stage which also is provided with shielding

14 A flow meter as claimed in claim 13, wherein the excitation electrode overlaps the measurement electrode.

15 A flow meter as claimed in claim 3, wherein the resistivity measuring device comprises:

(i) a pipe segment of insulating material;

(ii) an electric current generator which generates a current in the fluid flowing along the pipe;

(iii) two measurement electrodes spaced apart in the axial direction of the insulating segment and applied to an outside of the wall of the pipe to perform measurement by capacitive coupling so as to measure the electrical resistance therebetween; and

(iv) a measurement system for measuring the voltage between the measurement electrodes.

16 A flow meter as claimed in claim 15, wherein the measurement electrodes are annular electrodes placed around the insulating pipe segment.

17 A flow meter as claimed in claim 16, wherein a guard electrode surrounds each of the measurement electrodes.

18 A flow meter as claimed in claim 17, wherein the measurement system maintains the voltages of the guard electrodes at the same values as the voltages of the corresponding measurement electrodes.

19 A flow meter as claimed in claim 15, wherein the measurement system is configured such that the current flowing between the measurement electrodes is small enough to avoid affecting the measured voltage so that the potential difference between the two electrodes is equal to the potential difference between the points in the fluid facing the electrodes.

20 A flow meter as claimed in claim 19, wherein the measurement system comprises respective follower amplifiers associated with each of the measurement electrodes, each amplifier having an input connected to a measurement electrode and another input connected to a corresponding guard electrode and having an output connected to the guard electrode, the system further comprising means for determining the potential difference between the outputs of the two follower amplifiers.

21 A flow meter as claimed in claim 20, wherein each follower amplifier is connected to a corresponding measurement electrode by a core of a coaxial cable, and to a corresponding guard electrode by a shield of the coaxial cable.

22 A flow meter as claimed in claim 15, wherein the electric current generator comprises a toroidal emitter coil surrounding the tubing and a return electrical conductor interconnecting metal portions of the pipe situated respectively upstream and downstream from the insulating segment.

23 A flow meter as claimed in claim 15, further comprising a toroidal receiver coil surrounding the tubing to form a current measuring system.

24 A flow meter as claimed in claim 23, wherein each receiver coil is connected to an electronic circuit having low input impedance and the output from the electronic circuit delivers a signal that is proportional to the current flowing in the fluid.

25 A flow meter as claimed in claim 24, wherein the measurement system determines the ratio between the output from a voltage-measurement system that measures the voltage between the measurement electrodes and the output from a current-measuring system, the ratio being proportional to the resistance of the fluid.

26 A flow meter as claimed in claim 1, wherein the holdup measuring device is located approximately 1 – 10 pipe diameters downstream of the Venturi.

27 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough, the holdup measuring device comprising a capacitive sensor for determining the flow characteristics of a multi-phase fluid in a pipe, comprising at least one excitation electrode which part of the surface

defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe.

28 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough, the holdup measuring device comprising a device for capacitively measuring the dielectric constant of a two-phase fluid flowing along a pipe, comprising:

- at least one capacitive sensor comprising at least one excitation electrode which part of the surface defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe;
- power supply means connected to the excitation electrode of said capacitive sensor in order to apply an AC voltage to said excitation electrode;
- amplification means connected to both the excitation electrode and the measurement electrode in order to maintain said electrodes at the same potential and capacitively measure the current (i) output by said measurement electrode; and
- deducing means connected to said amplification means in order to deduce said dielectric constant from said current (i).

29 A device according to claim 28, in which said excitation electrode is connected to the general ground of said power supply means.

30 A device according to claim 28, in which an electrode is connected to the general ground of said power supply means, a floating ground being provided for said amplifying means for measuring the current.

31 A device according to claim 30, in which said amplifying means for measuring the current comprise a first amplification stage referenced relative to the potential of the

excitation electrode, and a second amplification stage organized to bring the reference of the output signal to the general ground.

32 A device according to claim 31, including shielding electrically connected to the excitation electrode, around the measurement electrode and around said first amplification stage.

33 A device according to claim 28, in which said excitation electrode covers the measurement electrode.

34 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough, the holdup measuring device comprising a device for capacitively measuring the volume fraction of a first fluid in a two-phase fluid flowing along a pipe, comprising:

- at least one device for capacitively measuring the dielectric constant of said fluid, said device comprising:
- at least one capacitive sensor comprising at least one excitation electrode which part of the surface defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe;
- power supply means connected to the excitation electrode of said capacitive sensor in order to apply an AC voltage to said excitation electrode;
- amplification means connected to both the excitation electrode and the measurement electrode in order to maintain said electrodes at the same potential and capacitively measure the current (*i*) output by said measurement electrode;
- calculating means connected to said amplification means in order to deduce said dielectric constant from said current (*i*) and calculate said volume fraction from said dielectric constant.

35 A device according to claim 34, comprising a plurality of devices for capacitively measuring the dielectric constant of said fluid, said plurality of devices being distributed over the periphery of a cross-section of said pipe.

36 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough, the holdup measuring device comprising a capacitive device for measuring the speed of a two-phase fluid flowing along a pipe, comprising:

- at least two devices that are disposed in different cross-sections of said pipe, said devices comprising:
- at least one capacitive sensor comprising at least one excitation electrode which part of the surface defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe;
- power supply means connected to the excitation electrode of said capacitive sensor in order to apply an AC voltage to said excitation electrode;
- amplification means connected to both the excitation electrode and the measurement electrode in order to maintain said electrodes at the same potential and capacitively measure the current (i) output by said measurement electrode; and
- deducing means connected to said amplification means in order to deduce said dielectric constant from said current (i); and
- correlating means connected to both of said two devices in order to establish a cross-correlation between the measurements delivered by said two devices and for deducing said speed therefrom.

37 A device according to claim 36, in which said at least two devices are disposed substantially along the same generator line of said pipe, and have a common excitation electrode.

38 A flow meter for multiphase flows, comprising a holdup measuring device having a Venturi located upstream thereof and separated therefrom by a distance that results in flow through the holdup measuring device being at least partially homogenized by the effect of the Venturi on the fluids flowing therethrough, the holdup measuring device comprising a device for capacitively measuring the flow rate of a fluid in a two-phase fluid flowing along a pipe, comprising

- at least one device for capacitively measuring the volume fraction of a said fluid, comprising:
- at least one device for capacitively measuring the dielectric constant of said fluid, said device including at least one capacitive sensor comprising at least one excitation electrode which part of the surface defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe; power supply means connected to the excitation electrode of said capacitive sensor in order to apply an AC voltage to said excitation electrode; amplification means connected to both the excitation electrode and the measurement electrode in order to maintain said electrodes at the same potential and capacitively measure the current (i) output by said measurement electrode; and calculating means connected to said amplification means in order to deduce said dielectric constant from said current (i) and calculate said volume fraction from said dielectric constant.
- at least one capacitive device for measuring the speed of a two-phase fluid flowing along a pipe, comprising:
- at least two devices that are disposed in different cross-sections of said pipe, said two devices including at least one capacitive sensor comprising at least one excitation electrode which part of the surface defines a cutout to allow free space in which at least one measurement electrode is disposed, said electrodes being arranged to be applied against said pipe; power supply means connected to the excitation electrode of said capacitive sensor in order to apply an AC voltage to said excitation electrode; amplification means connected to both the excitation electrode and the measurement electrode in order to maintain said electrodes at

the same potential and capacitively measure the current (i) output by said measurement electrode; deducing means connected to said amplification means in order to deduce said dielectric constant from said current (i);

- and correlating means connected to said capacitive device for measuring the speed, in order to establish a cross-correlation between the measurements delivered by capacitive device and to deduce said speed and thus said flow rate therefrom.

39 A method of measuring multiphase flows in a well, comprising measuring holdup in the flowing fluids downstream from a Venturi at a distance that results in flow being at least partially homogenized by the effect of the Venturi at the point at which holdup is measured.